

## **SPECIFICATION**

### **TITLE OF THE INVENTION**

CONDUCTIVE RESIN MOLDED PRODUCT HAVING INSULATING SKIN AND  
METHOD FOR FORMING THE SAME

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### **BACKGROUND OF THE INVENTION**

#### **Field of the Invention**

The present invention relates to a conductive resin  
molded product having an insulating skin produced by a  
10 composite consisting nonconductive resin and conductive  
material, and relates to a method for producing the same.

#### **Detailed Description of the Prior Art**

According to a conventional method, nonconductive resin  
15 is blended with conductive material such as carbon black and  
carbon fiber, or metal powder and metal fiber and the  
composite is then molded to produce a conductive resin molded  
product. (for example, refer to a non-patent literature 1).

Moreover, some conductive molded products are produced by  
20 injection-filling a mold with conductive resin in which a  
conductive compounding material such as metal fiber or metal  
powder is blended with nonconductive resin (for example,  
refer to the patent literature 1).

Non-patent literature 1: Ebihara, "Handbook of New  
25 Polymer Materials" P.69 to 74, Maruzen Co., Ltd. Sept. 20,  
1989

Patent literature 1: The Japanese Patent Laid-Open No.  
1993-131445, P.5

Conventionally, the conductive resin molded product has  
30 been produced by blending the conductive compounding material  
with the nonconductive resin to provide the resin with  
conductivity. However, as described in the non-patent  
literature 1 and the patent literature 1, most of the  
conventional conductive resins have adopted carbon black,

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carbon fiber, metal powder, or metal fiber which has remarkably large particles compared with the molecules of the resin as the conductive compounding material . When such conductive compounding material is blended to the extent that the resin is able to have conductivity, the molded product has conductivity even on its surface; therefore, insulation treatment of the surface is necessary depending on its use.

Moreover, the shape of the molded product tends to be restricted since the properties of the resin such as lightweight, flexibility, moldability, and processability are deteriorated to cause a hindrance in the production of the molded product by injection molding and to lower mechanical strength and the like. As a result, there is a problem that adoption of the above-mentioned technique to a product with a complex shape, even in the usage as a magnetic wave shield material (shield material for magnetic wave?).

#### **SUMMARY OF THE INVENTION**

The present invention is devised in order to solve the problems of the conventional conductive resin molded product as mentioned above. The purpose of the present invention is to expand the use of the conductive resin molded product and to provide a new conductive resin molded product having a new insulating skin which is usable as a base material for parts of electronic equipments such as laminated connectors as well as a method for producing the conductive resin molded product. For this purpose, a carbon nano material is adopted as a conductive compounding material to make the surface of the conductive resin molded product nonconductive from the resin.

The conductive resin molded product for the above-mentioned purpose according to the present invention comprises a resin insulating skin and a conductive core covered with said skin and, is composed of a composite containing a non-conductive resin and a carbon nano material. The resin

insulating skin is obtainable from molding said composite by controlling an amount of the carbon nano material to be composited with the non-conductive resin.

Moreover, a molding method for producing a conductive resin molded product according to the present invention comprises steps of;

plasticizing a composite material containing a non-conductive resin and a carbon nano material; and

injection molding thus plasticized material into a mold cavity to produce the conductive resin molded product comprising a resin insulating skin and a conductive core covered with said skin. In the method, an amount of the carbon nano material to be composited with the non-conductive resin is controlled so as to form the resin insulating skin in contact with a cavity face during said injection molding.

A ratio of the carbon nano material to be composited with said non-conductive resin dose not exceed 15 weight % based on the composite to form the resin insulating skin in contact with a cavity face during said injection molding.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig.1 is an enlarged cross sectional view of a part of a conductive resin molded product having an insulating skin according to the present invention.

Fig.2 is an explanatory illustration of behavior of a composite conductive material flowing in the cavity up to completion of the filling.

#### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

Fig.1 shows an enlarged cross sectional view of a part of a conductive resin plate mentioned as an example of the present invention, and the reference numeral 1 is an insulating resin skin, the reference numeral 2 a conductive core coated with the insulating skin 1. The conductive resin

plate is obtained by injection molding a composite conductive material with which a carbon nano material is blended. It is a flat plate with a thickness of 1.5 to 3.0 mm and an upper face area of 30 to 40 cm<sup>2</sup>, and consists of the insulating skin 1  
5 with a thickness of 0.1 to 0.2 mm and the core 2 having conductivity brought by the carbon nano material inside of it. The surface of the conductive resin plate has an insulation characteristics of 10<sup>10</sup> Ωcm or more in electric resistance.

Even if the above-mentioned conductive resin plate is in  
10 the state insulated by the surface resin, an end of a conductive part breaks through the insulating skin 1 and reaches the core 2 when the part sticks into the resin plate, therefore, the part becomes to be electrically connected with the conductive core 2. Such conductive resin plate can be  
15 used as an electromagnetic wave shield material having an insulating skin as it is, and can also be used as a base material for a laminated connector. The conductive resin plate is also applicable to many other uses than those.

Since the conductive core 2 is coated with the insulating  
20 skin 1 in the use as the electromagnetic wave shield material, it is unnecessary to take into account electric damage caused by contact with other electronic equipment, parts, or the like. Moreover, since the surface is made by resin, the surface treatment such as mirror finishing of the surface and  
25 embellishment is also easily carried out by a conventional treatment method employed for the resin up to now.

Although an illustration is omitted here, the laminated connector can easily be manufactured by adhering a necessary number of stack sheets together into a laminated plate, cutting this at equal intervals into plate bodies in which the  
30 insulating skin and the conductive core are alternately placed, and only cutting the plate body to a necessary dimension in the direction orthogonal to the insulating skin. Thus, a connector constituted of the conductive cores of the

number equal to the stacked sheets is formed into the laminated type connector divided by the insulating skins.

In a conventional laminated connector made of rubber, after a thin film of rubber provided with conductivity is alternately laminated with a thin film of insulating rubber and fix them together, the fixed one is then cut to manufacture the rubber-made laminated connector. On the other hand, using the conductive resin molded product having the insulating skin 1 eliminates the alternate lamination of the insulating skins, and the laminated plate is easily formed by mutual adhesion between the insulating skins, therefore, the manufacture is more simplified than that using rubber, and the laminated type resin connector which has been regarded as difficult to manufacture can be provided at a lower cost.

Moreover, the carbon nano material is ultrafine particulate and, in a blending quantity not exceeding 15 weight %, since it does not damage the characteristics of resin and injection molding can be performed under the conditions set according to a resin, special techniques are not required for molding and there is little change in the properties. Therefore, the resin does not lose its characteristics by the molding, and the conductive resin plate further improved in dimensional accuracy can be obtained as the base material for parts.

In order to produce the above-mentioned conductive resin plate by injection molding, composite conductive material blended the carbon nano material not exceeding 15 weight % with nonconductive resin is used. As the nonconductive resin, thermoplastic resin used as a molding material, for example, polyethylene, polyester, polyamide, polycarbonate, ABS resin, and liquid crystal polymer can be used.

Moreover, as a carbon nano materials to be blended with the nonconductive resin, nano fiber (having a diameter of 50 - 200 nm, preferably, 80 - 150 nm, and aspect ratio of 100 -

1000), nano carbon tube (having a diameter of 1 - 50 nm, preferably, 10 - 50 nm, and aspect ratio of 100 - 1000), fullerene (having a diameter of 0.7 - 1 nm), or the like can be mentioned. Since they are more ultrafine particulate than  
5 the metal powder and metal fiber which have been blended as the conductive material in the composite conductive material, they have good conformability to the resins, and have a good dispersion efficiency by kneading. As a result, the properties of the resins such as flexibility, moldability, and  
10 processability are not lost.

In the aforementioned case, it is most preferable that such composite conductive material is pelletized beforehand and supplied to an injection molding machine. However, there is no difficulty in the molding even if both of the resin and  
15 carbon nano material are sufficiently kneaded by a kneader and then supplied to the injection molding machine. Therefore, the composite conductive material may be supplied by either method.

The molding conditions of the injection molding machine  
20 such as temperature of a heating cylinder, cooling temperature of a product mold, screw speed, injection speed and pressure are arbitrarily set according to the kind of resin adopted there. After the composite conductive material supplied from a hopper into the heating cylinder with a built-in screw is  
25 plasticized (melted and kneaded) by ordinary injection molding operation, the material is measured and then filled by injection into the mold by forward stroke of the screw.

Each illustration in Fig.2 shows the behaviors of the molten body 13 of the composite conductive material flowing in  
30 the cavity 12 of the mold 11 before completing the filling, and as shown in the illustration (A), the molten body 13 flows at the highest speed in the center part, and flows slower as it approaches to a cavity surface 12a. Moreover, as shown in the illustration (B), the molten body is increased in

viscosity due to cooling of the mold 11 and gets difficult to flow, and the resin is cooled and solidified into the surface layer (the skin).

From this difference in flow, a velocity gradient, namely, a rate of shear arises between the center part of the molten body 13 and the contact part with the cavity surface 12a. Thus, the resin on the cavity surface 12a which is getting cooled and solidified is extended in the direction of the flow because of large shearing stress applied on it from the molten body 13 being press-fitted, and at the same time, the carbon nano material on the skin side is also pulled and aligned in the direction of the flow, and also becomes to be easily centralized in the center of the molten body from the skin 13a.

On the other hand, since the core 13b is little influenced by the shearing stress and the carbon nano material exhibits anisotropy, conductivity appears. It is difficult to express conductivity by using fullerene, but an effect is obtained by using another carbon nano material together. This phenomenon is conditional on a blending quantity of a carbon nano material; the blending quantity is preferred to be 5 - 15 weight %. In the case of a blending quantity exceeding 15 weight %, conductivity appears also on the skin 13a and this makes it difficult to form the insulating skin 13a out of the resin. After having completed filling the resin, the resin is cooled and solidified into the conductive resin plate comprising the skin 13a of the resin having non-conductivity and the conductive core 13b coated with the skin 13a as shown in the illustration. Namely, the insulating skin formed out of resin and the core coated with the insulating skin are formed by the difference in fluidity between the resin and the carbon nano material flowing in the cavity and shearing stress on the cavity surface obtained by controlling a blending quantity of a carbon nano material.

### Example of the Embodiment

Conductive resin molded product

5	Form and dimensions;	Flat plate (rectangular shape), Plate thickness: 2.0mm Plane area of its upper face: 36cm <sup>2</sup>
	Resin;	Polypropylene
	Compounding ingredient;	Carbon nano tube, 10nm diameter, 1 to 10μm long
10	Blending quantity;	10 weight %
	Conductivity (volume resistivity);	Surface: 10 <sup>10</sup> Ωcm or more, Inside : 10 <sup>3</sup> Ωcm or less
15	Injection molding machine;	PS40 (manufactured by NISSEI PLASTIC INDUSTRIAL CO., LTD.)
	Molding conditions ;	Plasticizing temperature 210°C Injection speed 100mm/s Injection pressure 100MPa Mold temperature 30°C
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